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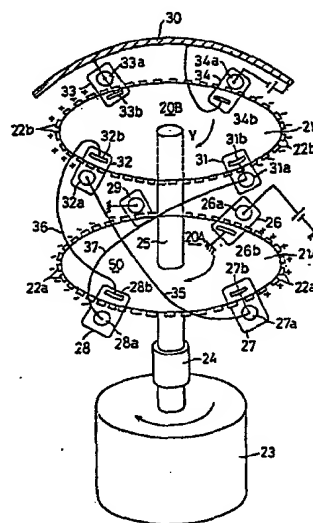
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### 54 ELECTROSTATIC HIGH-VOLTAGE GENERATOR.

57 An electrostatic high-voltage generator which is accommodated in an SF<sub>6</sub> gas-filled container and which mechanically transports static electricity using charge carrier units to store the electric charge on a high-voltage electrode (30). Charge carrier units (20A, 20B) consisting of insulating discs (21A, 21B) are stacked in a direction at right angles with the direction of carrying the charge, the insulating discs having conductive pellets (22a, 22b) arranged around the peripheries thereof to carry the static charge. The electric charge carried to the charge carrier unit (20A) of the first stage is carried to the charge carrier unit (20B) of the next stage by a charge transfer unit (50), and is further carried to the high-voltage electrode (30) by an inductor (33) of the high-voltage side. Thus, a very high voltage can be generated by a small apparatus.



EP 0 229 843 A1

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## ELECTROSTATIC HIGH-VOLTAGE GENERATOR

TECHNICAL FIELD

This invention relates to an electrostatic high-voltage generator wherein an electrostatic charge is transported mechanically and is accumulated in a high-voltage electrode for obtaining a high-voltage.

BACKGROUND ART

As for an electrostatic high-voltage generator in which an electrostatic charge is transported mechanically and accumulated in a high voltage electrode for obtaining a high voltage, there has been known, for instance, a pellet chain type high-voltage generator, a disc type high voltage generator or the like.

A principle of the pellet chain type high voltage generator is such that, as shown in fig. 4, a large number of conductive pellets 1 and insulating members 2 are connected together alternately and flexibly to form a charge carrier unit 3 of a pellet chain, so that if the charge carrier unit 3 is moved between a ground side pulley 4 and a high-voltage side pulley 5, and a negative voltage is applied to a ground side inductor 6 from an electric source 7, a positive electric charge is induced electrostatically to each conductive pellet 1, while a negative electric charge is repelled to escape to the ground side pulley 4, and thus the positive electric charge remains at each pellet 1 and is carried from the low-voltage side pulley 4 towards a high voltage electrode 8 and is accumulated

110501  
2

therein to result in a high voltage.

In addition, similarly, a negative electric charge is given to each pellet 1 of the charge carrier chain 3 from a high-voltage side inductor 9 associated with the high-voltage electrode 8 and is carried to the ground side pulley 4, and thus by reciprocating the charge carrier unit 3 between the ground side pulley 4 and the high voltage side pulley 5, so that there can be carried doubled electric charges.

A principle of the disc type high-voltage generator is such that, as shown in Fig. 5, a charge carrier unit 3 is constructed into such a disk type one that conductive pellets 1 are disposed along on a circumferential edge of a rotary insulating disc 10, so that in the course of turning of the insulating disc 10, a positive electric charge is given to each pellet 1 from a conductive pulley 12 of a ground side inductor 11, and this positive electric charge carried by each pellet 1 is received by a conductive pulley 14 of a high-voltage side inductor 13 and is accumulated in a high-voltage electrode 8 to result in a high voltage.

In addition, a negative electric charge is given to each pellet 1 from a conductive pulley 16 of another high-voltage side inductor 15 in the high-voltage electrode 8, and is received by a conductive pulley 18 of a ground side inductor 17 provided on the ground side, and thus by one round of the insulation disc 10 of the charge carrier unit 3 between the ground side inductors 11 and 17, there can

be carried doubled electric charges.

The pellet chain type and the disc type high-voltage generators shown principally in Figs. 4 and 5 are so arranged as to be accommodated in respective containers each of which is filled with a  $\text{SF}_6$  insulation gas of  $7 \text{ kg/cm}^2$  in pressure, and the highest potential gradient in the direction of carrying the charge is  $2 \text{ MV/M}$ , in the  $\text{SF}_6$  insulation gas of the pressure of  $7 \text{ kg/cm}^2$ . This highest potential gradient of  $2 \text{ MV/M}$  is regulated by the shape, the size and the number of the disposed conductive pellets 1, the insulating resistance force of the insulating members 2 and that of the insulation disc 10 in Figs. 4 and 5.

Accordingly, in order to obtain a higher voltage in the pellet chain type and the disc type high voltage generators, there is no means other than heightening the insulating gas pressure, elongating the distance in the charge carrying direction of the chain or enlarging the diameter of the insulation disc in Fig. 4 and Fig. 5.

However, in any of the types of high-voltage generators, the mechanism thereof are accommodated in the pressure container of the  $\text{SF}_6$  insulating gas in order to obtain a small-sized one as a whole, so that, if the gas pressure is heightened, the maintenance of the insulating gas and the constructional design of the pressure container become difficult.

The increase in the carrying distance of the chain and the diameter of the insulating disc involves an increase in installation area, which is not always considered as an

1050

economical design.

#### OBJECT OF INVENTION

An object of this invention is to provide an electrostatic high-voltage generator which can obtain a higher voltage and can be constructed into a small-sized one without causing an increase in installation area as much as possible.

#### DISCLOSURE OF THE INVENTION

In view of the fact that the highest potential gradient in the charge carrying direction is 2 MV/M in the SF<sub>6</sub> insulating gas of 7 kg/cm<sup>2</sup> in pressure but a potential gradient in a direction at right angles with the direction of carrying the charge is 20 MV/M, an electrostatic high-voltage generator of this invention is characterized in that plural layers of charge carrier units are stacked in a direction at right angles with the charge carrying direction, and a charge carrying transfer means is provided between respective adjacent ones of the charge carrier units.

#### BRIEF DESCRIPTION OF DRAWINGS

Fig. 1 is a perspective view of one embodying example of this invention electrostatic high-voltage generator, Fig. 2 is a perspective view of another embodying example thereof, Fig. 3 is a perspective view of further another embodying example of the same, Fig. 4 is a top plan view of a conventional pellet chain type electrostatic high-voltage generator, and Fig. 5 is a top plan view of a conventional disc type electrostatic high voltage generator.

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BEST MODE OF CARRYING OUT THE INVENTION

This invention will be explained with reference to embodying examples thereof shown in Figs. 1 - 3 as follows:-

First, a principle of an electrostatic high-voltage generator according to this invention will be explained with reference to a disc type one thereof shown in Fig. 1.

Two disc type charge carrier units 20A, 20B are such that a large number of conductive pellets 22a, 22b are arranged along on circumferential edges of insulating discs 21A, 21B, and are arranged stacked with a space left therebetween, on an insulating rotary shaft 25 connected directly to a rotary shaft 24 of a driving motor 23 so as to be turnable at a predetermined speed by the driving motor 23.

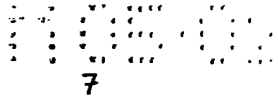
Around the rotary insulating disc 21A of the charge carrier unit 20A of the first stage, there is arranged a ground side inductor 26 for charging which comprises a conductive pulley 26a arranged to contact the pellets 22a thereto by turning of the insulating disc 21A and an inductor electrode 26b, a first inductor 27 for charge carrying transfer which is provided at a predetermined interval from the foregoing inductor 26 and comprises a conductive pulley 27a arranged to contact the pellets 22a and an inductor electrode 27b, a fourth inductor 28 for charge carrying transfer which is provided at a predetermined interval from the foregoing inductor 27 and comprises a conductive pulley 28a arranged to contact the pellets 22a and an inductor electrode 28b, and a ground side conductive pulley 29 for

110501  
6

current collection provided at a predetermined interval from the foregoing inductor 28.

An upper portion of the charge carrier unit 20B of the second stage is covered with a high-voltage electrode 30, and around the insulating disc 21B thereof, there is arranged a third inductor 31 for charge carrying transfer which comprises a conductive pulley 31a and an inductor electrode 31b, a second inductor 32 for charge carrying transfer which is provided at a predetermined interval from the foregoing inductor 31 and comprises a conductive pulley 32a and an inductor electrode 32b, a high-voltage side inductor 33 for current collection which is provided at a predetermined interval from the foregoing inductor 32 and comprises a conductive pulley 33a and an inductor electrode 33b, and an inductor 34 for negative electric charge charging which comprises a conductive pulley 34a for charging a negative electric charge to the pellets 22b and an inductor electrode 34b.

The conductive pulley 26a of the ground side inductor 26 for charging provided on the first stage charge carrying unit 20A is arranged to be given a positive electric charge, and the inductor electrode 26b thereof is grounded. The conductive pulley 27a of the first inductor 27 for charge carrying transfer is electrically connected to the inductor electrode 27b, and the conductive pulley 27a of this inductor 27 is connected, through a conductor 35, to the conductive pulley 32a of the second inductor 32 for charge carrying transfer of the charge



carrying unit 20B of the second stage. The inductor electrode 32b of the second inductor 32 for charge carrying transfer is connected, through a conductor 36, to the inductor electrode 28b of the fourth inductor 28 for charge carrying transfer.

Additionally, the conductive pulley 28a of the fourth inductor 28 for charge carrying transfer is connected, through a conductor 37, to the conductive pulley 31a of the third inductor 31 for charge carrying transfer. In addition, the conductive pulley 31a and the inductor electrode 31b of the third inductor 31 for charge carrying transfer are connected electrically one to another, and the conductive pulley 33a and the inductor electrode 33b of the high voltage side inductor 33 for current collection are interconnected together electrically. The inductor electrode 34b of the inductor 34 for negative electric charge charging is connected to the high-voltage electrode 30.

Thus, by the first, second, third and fourth inductors 27, 32, 31, 28 for charge carrying transfer and the mutual connection relationship between those, there is constructed such a charge carrying transfer unit 50 between the charge carrying unit 20A of the first stage and the charge carrying unit 20B of the second stage that is the characteristics of this invention.

Next, an operational principle of the electrostatic high-voltage generator of this invention constructed as above will be explained as follows:-



110501  
8

Now, the charge carrier units 20A, 20B are rotated in the direction shown by an arrow Y by the driving motor 23, and thereby a positive electric charge is charged, from the conductive pulley 26a of the ground side inductor 26 for charging, to the conductive pellets 22a of the insulating disc 21A of the first stage charge carrying unit 20A. This positive electric charge is carried by the pellets 22a and is completely received by the conductive pulley 27a of the first inductor 27 for charge carrying transfer.

Since the pulley 27a and the inductor electrode 27b of the inductor 27 are interconnected electrically, the collected positive electric charges are passed through the conductor 35 and are transferred from the conductive pulley 32a of the second inductor 32 for charge carrying transfer to the pellets 22b of the charge-carrier unit 20B of the second stage, and are accumulated in the high-voltage inductor 30 through the conductive pulley 33a of the high-voltage inductor 33.

Meanwhile, at the second inductor 32 for charge carrying transfer, a negative electric charge is induced electrostatically at the inductor electrode 32b, while a positive electric charge is collected to the inductor electrode 28b of the fourth inductor 28 for charge carrying transfer which is electrically connected through the conductor 36 to the foregoing inductor electrode 32b, and thus the two electrodes 32b, 28b are balanced one with another in respect of electric charges. This balance phenomenon in respect of electric

FIG. 1

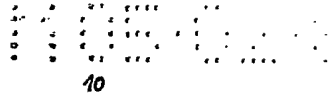
9

charges is convenient for carrying a negative electric charge of the high-voltage side charge carrier unit 20B of the second stage to the ground side first stage charge carrier unit 20A.

Meanwhile, a negative electric charge is charged to the pellets 22b of the charge carrying unit 20B of the second stage from the conductive pulley 34a of the inductor 34 for negative electric charge charging provided on the high-voltage electrode 30. This negative electric charge is received by the conductive pulley 31a of the third inductor 31 for charge carrying transfer, when each pellet is passed through the inductor 31 in accordance with the turning of the insulating disc 21B. This negative electric charge is transferred, through the conductor 37, from the conductive pulley 28a of the fourth inductor 28 for charge carrying transfer to the pellets 22a of the insulating disc 21A. The negative electric charges of these pellets 22a are collected at the ground side conductive pulley 29 for current collection according to the turning of the insulating disc 21A.

Thus, there is obtained, at the high-voltage electrode 30 provided above the charge carrying unit 20B of the second stage, a double voltage 2E which is double as high as the high voltage E obtained at each of the charge carrier units 20A, 20B. If any desired number of the insulation discs of the charge carrying units are stacked in layers, a high voltage of twice, three times and so on can be generated in proportion to the number of the layers.

Additionally, in fig. 1, the positive electric charges



of the pellets 22a between the inductors 26, 27 of the charge carrier unit 20A of the first stage and the negative electric charges of the pellets 22b between the inductors 34, 31 of the charge carrier unit 20B of the second stage are opposite one to another, and a row of the negative electric charges between the inductors 28, 29 of the charge carrying unit 20A of the first stage and a row of the positive electric charges between the inductors 32, 33 of the charge carrying unit 20B of the second stage are opposite one to another, so that the two units 20A, 20B are balanced one with another electrostatically, and there is not generated any load on the driving motor 23, and the two units 20A, 20B are driven stably and the electric charges can be carried with a high efficiency.

In an embodying example shown in fig. 2, three stages of charge carrier units 20A, 20B, 20C are put one upon another so as to generate a threefold high-voltage.

A first charge carrying transfer unit 50A is provided between the charge carrying unit 20A of the first stage and the charge carrying unit 20B of the second stage, and a second charge carrying transfer unit 50B is provided between the charge carrying unit 20B of the second stage and the charge carrying unit 20C of the third stage.

A positive electric charge given to the conductive pellet 22a of a first stage insulating disc 21A from a ground side inductor 26 for charging is transferred, in conjunction with turning of the insulating disc 21A, through the first charge carrying transfer unit 50A, to conductive pellets 22b of a



11

second stage insulating disc 21B. Further, this positive electric charge is transferred, in conjunction with turning of the second stage insulating disc 21B, through second charge carrying transfer unit 50B to conductive pellet 22c of the third insulating disc 21C, and is finally collected at a high-voltage side inductor 33 for being stored in a high-voltage electrode 30. The voltage of this high-voltage electrode 30 is three times as high as the voltage of a single charge carrier unit.

If, in fig. 2, the intensity of electric field along on the charge carrying path of each of the respective charge carrier units 20A, 20B, 20C is assumed to be  $E_{11}$ , a practical value of this intensity of electric field  $E_{11}$  is below 2 MV/M. If each of respective potential gradients generated between the charge carrying unit 20C of the third stage and charge carrying unit 20B of the second stage, and between the charge carrying unit 20B of the second stage and the charge carrying unit 20A of the first stage is assumed to be  $E_{\perp}$ , a value of the potential gradient  $E_{\perp}$  can be made above 20 MV/M. This potential gradient  $E_{\perp}$  secures a withstanding voltage of above 10 times as much as the intensity of electric field intensity  $E_{11}$ , and this is an important characteristic point of this invention for realizing an ultra high potential gradient generator.

In another embodying example shown in Fig. 3, respective charge carrier units 20A, 20B, 20C are formed into pellet chain type ones comprising pulleys 51a, 51a', 51b, 51b' and

1050  
12

51c, 51c', and pellet chains 52a, 52b and 52c arranged to be moved in the directions shown by arrows Y.

Also in this pellet chain type electrostatic high-voltage generator, if a positive electric charge is given to pellets of the pellet chain 52a of the first stage from a ground side inductor 26, the same is transferred to the pellet of the pellet chain 52b of the second stage through a first charge carrying transfer unit 50A, and is further transferred to the pellet chain 52C of the third stage through a second charge carrying transfer unit 50B, and is finally stored in a high voltage electrode 30 for obtaining a high-voltage. The voltage of this high-voltage electrode 30 is three times as high as the voltage obtained by a single charge carrier unit.

Also in the case of the pellet chain type one of Fig. 3, the relation between the intensity of electric field  $E_{11}$  along on the charge carrying path and the potential gradient  $E_{\perp}$  in the direction at right angles with the charge carrying path is entirely equal to that in the case of the disc type one of Fig. 2. Additionally, in Figs. 2 and 3, there has been shown only the manner of transporting of the positive electric charges, but there can be obtained a double electric current by giving negative electric charge in a returning direction of each of the charge carrying units 20A, 20B, 20C, as shown in Fig. 1.

Though a concrete construction is not illustrated, a mechanism including the charge carrier units shown in any of

Figs. 1, 2 and 3 is accommodated in a container filled with a  $\text{SF}_6$  insulating gas, so that the same may be constructed into a compact electrostatic high-voltage generator by the gas insulated construction. Additionally, it is possible to transfer the electric charges stably by connecting a resistance to the middle portion of each of the conductors 35, 36, 37 for interconnecting between the charge carrying transfer inductors as shown in Fig. 1 and thereby each circuit is increased in weight.

#### EFFECT OF INVENTION

Thus, according to this invention, plural layers of charge carrier units are stacked in a direction at right angles with the direction of carrying the charge, and there is provided, between respective adjacent ones of those charge carrier units, a charge carrying transfer unit for transfer the electric charge carried in one unit to the adjacent unit, so that there can be obtained an ultra high-voltage type electrostatic high-voltage generator fully utilizing that the highest potential gradient in the direction of stacking of those units is above 20 MV/M, and additionally a volume in the direction of stacked units is increased, but the installation area is not especially increased, so that the whole thereof can be constructed economically into a small-sized one.

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1. An electrostatic high-voltage generator in which an electrostatic charge is transported mechanically and is stored on a high-voltage electrode, characterized in that plural layers of charge carrier units, each serving to transport the foregoing electrostatic charge, are stacked in a direction at right angles with the direction of carrying the charge, and there is provided, between respective adjacent ones of those units, a charge carrying transfer unit for transferring an electric charge carried in one unit to the other unit adjacent thereto.

2. An electrostatic high-voltage generator as claimed in claim 1, wherein the charge carrying transfer unit comprises an inductor for receiving an electric charge carried by conductive pellets of one charge carrier unit, and another inductor which is electrically connected to the foregoing inductor and arranged to serve to give the electric charges received thereby to the adjacent charge carrier unit.

3. An electrostatic high-voltage generator as claimed in claim 1, wherein the charge carrying transfer unit comprises a first inductor for receiving a positive electric charge carried by conductive pellets of one charge carrier unit, a second inductor which is electrically connected to the first inductor and serves to give the positive electric charge received thereby to conductive pellets of another charge carrier unit adjacent thereto, a third inductor for receiving a negative electric charge carried by conductive pellets of the foregoing another charge carrier unit,

and a fourth inductor which is electrically connected to the third inductor and arranged to serve to give a negative electric charge received thereby to the conductive pellets of the foregoing one charge carrier unit.

4. An electrostatic high-voltage generator as claimed in claim 3, wherein the first, second, third and fourth inductors constituting the charge carrying transfer unit are respectively composed of conductive pulleys arranged to contact conductive pellets of respective charge carrier units and respective inductor electrodes facing the respective conductive pulleys through the respective conductive pellets, and the first and third inductors are so arranged that, in each thereof, the conductive pulley and the inductor electrode are electrically connected together, and the conductive pulleys of the first and second inductors are electrically connected together, and the conductive pulleys of the third and fourth inductors are electrically connected together, and the inductor electrodes of the second and fourth inductors are electrically connected together.

5. An electrostatic high-voltage generator as claimed in any of claims 1 - 4, wherein each charge carrier unit is a pellet chain type one.

6. An electrostatic high-voltage generator as claimed in any of claims 1 - 4, wherein each charge carrier unit is a disc type one.



FIG. 1

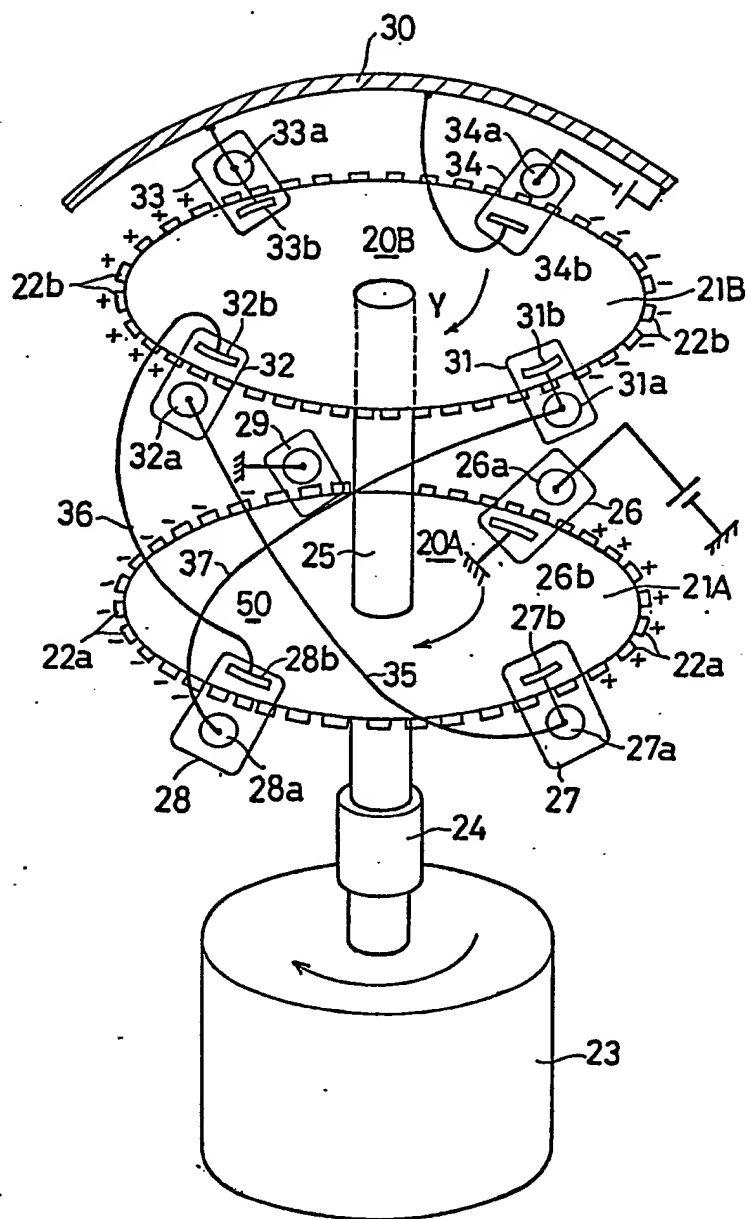


FIG. 2

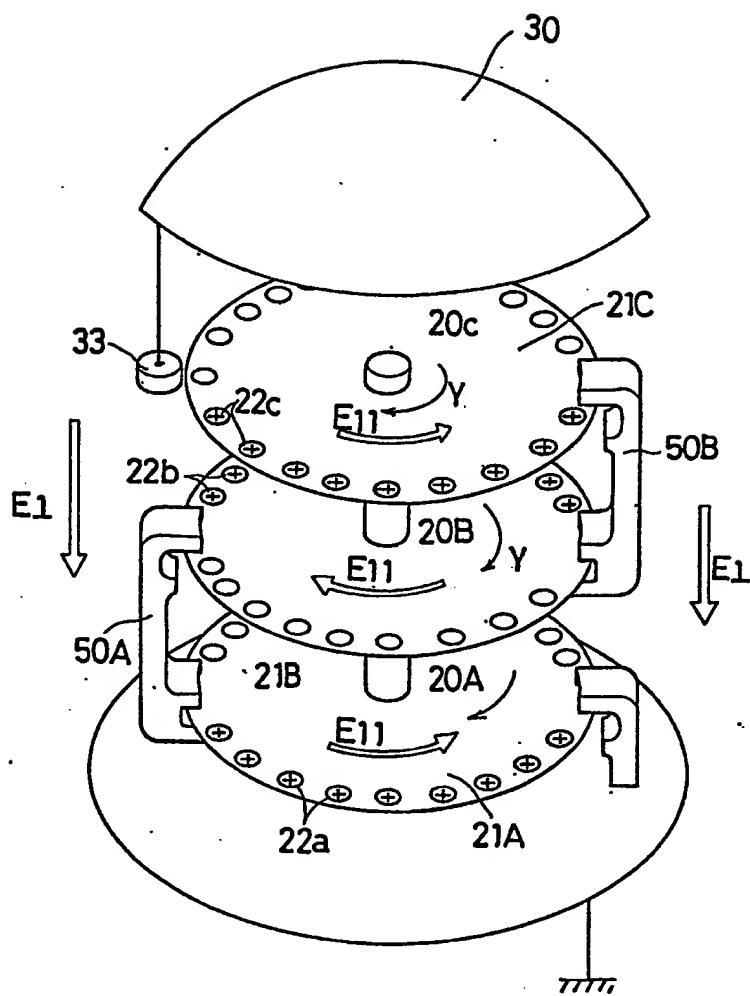


FIG. 4<sup>3/3</sup>

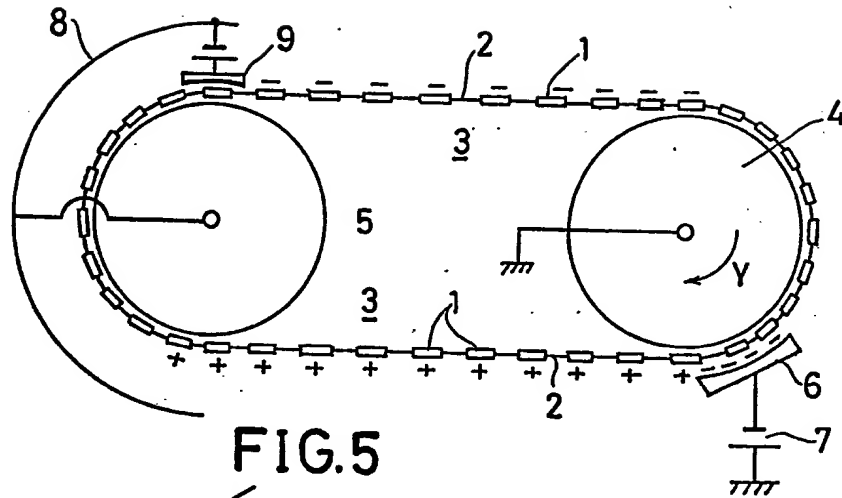
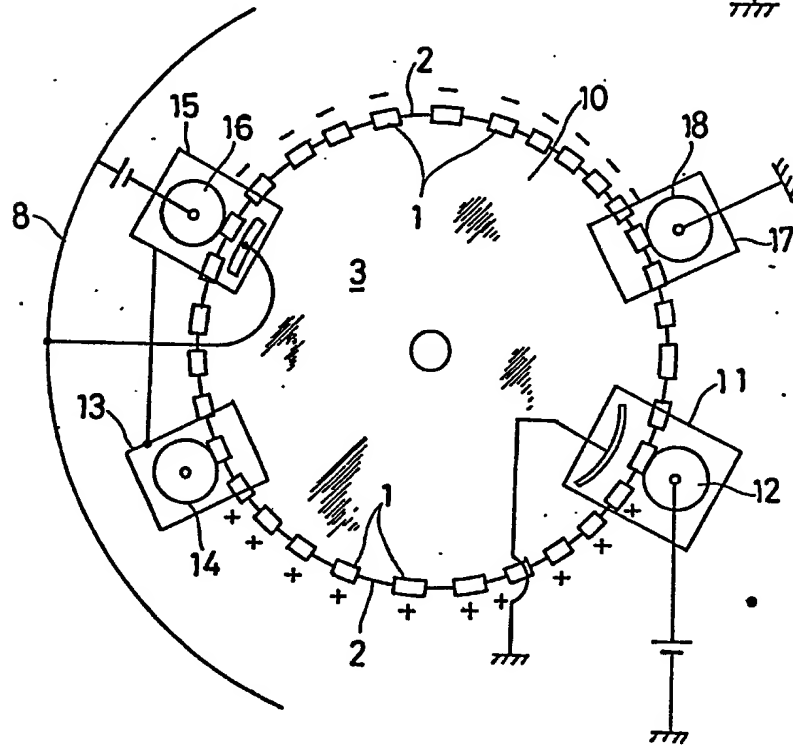


FIG. 5



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## INTERNATIONAL SEARCH REPORT

International Application No. PCT/JP86/00292

<b>I. CLASSIFICATION OF SUBJECT MATTER</b> (if several classification symbols apply, indicate all) <sup>1</sup>		
According to International Patent Classification (IPC) or to both National Classification and IPC		
Int.Cl <sup>4</sup> H02N1/08		
<b>II. FIELDS SEARCHED</b>		
Minimum Documentation Searched <sup>5</sup>		
Classification System	Classification Symbols	
IPC	H02N1/06-1/12	
Documentation Searched other than Minimum Documentation to the extent that such Documents are included in the Fields Searched <sup>6</sup>		
Jitsuyo Shinan Koho		1926 - 1985
Kokai Jitsuyo Shinan Koho		1971 - 1985
<b>III. DOCUMENTS CONSIDERED TO BE RELEVANT <sup>11</sup></b>		
Category <sup>12</sup>	Citation of Document, <sup>13</sup> with indication, where appropriate, of the relevant passages <sup>14</sup>	Relevant to Claim No. <sup>15</sup>
Y	JP, A, 57-40380 (Nippon Shinku Gijutsu Kabushiki Kaisha) 5 March 1982 (05. 03. 82) Page 2, upper left column, lines 3 to 8, page 2, lower right column, line 9, page 3, upper left column, line 19 (Family: none)	1 - 6
Y	US, A, 3035221 (High Voltage Engineering Co.) 15 May 1962 (15. 05. 62) Column 2, lines 6 to 19 (Family: none)	1 - 6
<p><sup>16</sup> Special categories of cited documents: <sup>17</sup></p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation (or other special reason (as specified))</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> <p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art</p> <p>"Z" document member of the same patent family</p>		
<b>IV. CERTIFICATION</b>		
Date of the Actual Completion of the International Search <sup>18</sup>	Date of Mailing of this International Search Report <sup>19</sup>	
August 29, 1986 (29. 08. 86)	September 16, 1986 (16. 09. 86)	
International Searching Authority <sup>20</sup>	Signature of Authorized Officer <sup>21</sup>	
Japanese Patent Office		